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THE USE OF DERRICK CRANES

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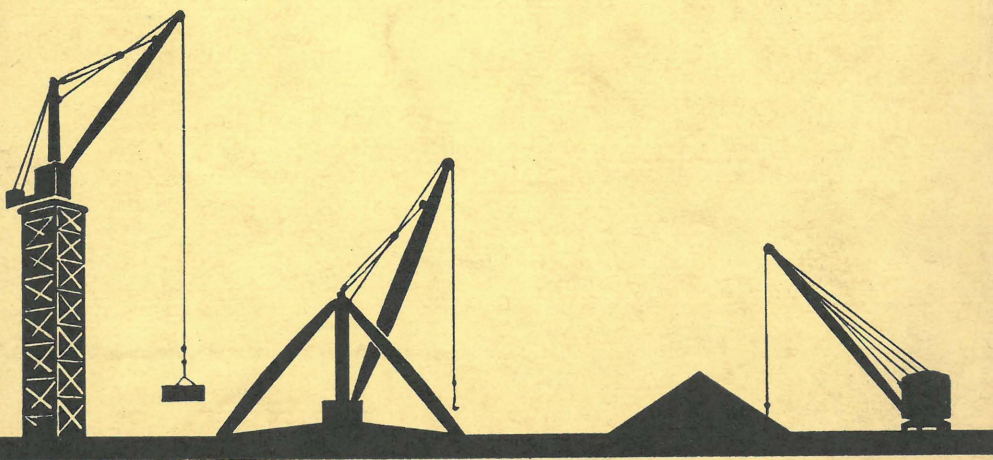

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SAFETY PAMPHLET No. 15

(3rd Edition)

THE USE OF DERRICK CRANES

LONDON: HIS MAJESTY'S STATIONERY OFFICE

1949

(Reprinted 1950)

CONTENTS

THE USE OF DERRICK CRANES

This pamphlet deals principally with Scotch and Guy Derrick cranes but many of the points dealt with are appropriate to other types of jib crane. Investigations of crane accidents over a number of years have shown that many fatal and other serious accidents could have been prevented by the observance of reasonable precautions.

Among the common causes of crane accidents and crane failures have been improper use, careless handling, or failure on the part of users to carry out necessary maintenance work. Such comparatively frequent occurrences as fractures of parts, failure of ropes or chains, failure of anchoring appliances or overturning could, in many cases, be avoided by periodic thorough examination with replacement of defective parts and by proper use.

Such examinations, and some of the other steps recommended in this pamphlet, are required by law in factories, in warehouses, at docks, in shipbuilding yards and on building operations—see Section 24, Factories Act, 1937; S.R. & O. 1934, No. 279 (Docks) ; 1931, No. 133 (Shipbuilding) ; and S.I., 1948, No. 1145 (Building).

NEW CRANES

When ordering a new crane, the purchaser should give the crane maker full information as to the use to which the crane is to be put, including any special circumstances or conditions of work which might, even if only on rare occasions, be anticipated. A crane well designed for its ordinary work may be quite unsuited for exceptional duty (e.g., working a grab in clay or other heavy ground) unless provision has been made for this in the original design. Where a mobile crane may have to operate on soft, uneven or sloping ground or where there may be a liability for loads to swing when travelling, it is advisable to employ a crane having a higher rated capacity than the loads which will have to be manipulated (see Section dealing with Overturning —Mobile Cranes).

SECOND-HAND CRANES

The purchase of a second-hand crane requires much more care than that of a new crane. The jib may be longer than that originally fitted but no reduction made in the safe working load as marked on the crane. In some cases, in changing ownership the nominal safe working load has been increased and failures have consequently resulted ; in others, broken or badly corroded parts, such as pins or bolts, have remained undetected or have been replaced by parts not of the same size or strength. It is therefore most important, when purchasing a second-hand crane, that as much as possible of its history should be known and that a thorough examination should be made by a person fully competent for such duty. Section 24 of the Factories Act, 1937, the Docks Regulations and the Shipbuilding Regulations require every crane, new or second-hand, to be tested and examined before being taken into use and the Building Regulations require every crane to have been tested and thoroughly examined within the previous four years and subsequent to any substantial alteration or repairs. The maker of the crane will doubtless be willing and is generally able to give any information desired concerning a crane (the serial number should, whenever available, be quoted when the request is made) but in any case, unless the purchaser has a sufficient knowledge of cranes, expert opinion should be obtained as to the condition of such a crane and its suitability for the proposed use. The engineering insurance companies, as well as the various crane makers, have staffs capable of making the necessary examinations and tests of cranes.

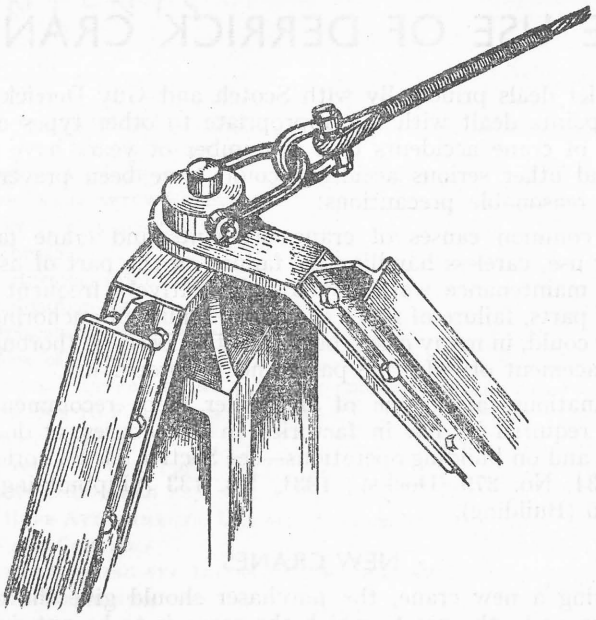


FIG. 1.—Showing that the left hand stay, viewed from behind, is erected first.

JIBS OF DIFFERENT LENGTHS

When a crane is used at different times with jibs of different lengths, particulars of the lengths and appropriate safe working loads should be plainly marked in a prominent place on the crane and the crane driver should be definitely advised when the longer jib is in use. When the jib length is altered the accuracy of safe load and radius indicators should be checked. Where practicable, the radius-safe load indicator should adjust itself automatically when the jib length is changed.

ERECTION OF A CRANE

All ropes and lifting gear used for the erection of a crane should be of sound material and adequate strength, and be properly secured.

Most cranes are erected by the makers or other persons familiar with the points requiring special attention ; if doubt on any point arises application should be made to the makers (quoting the serial number of the crane) for the necessary instructions. A simple point in the erection of Scotch derrick cranes which, if neglected, might reduce the safety of the crane, is the arrangement of the back legs or stays. These stays are of different lengths and are not interchangeable. The shorter leg is the left hand one (viewed from the back of the crane) and must be erected first (*see* Fig. 1). If the stays are wrongly erected the mast will be out of plumb ; it may foul the stays and in addition the slewing angle may be reduced.

When a crane is properly erected, all ropes should be clear of the structure thus avoiding chafing and interference with the smooth operation of the crane.

All pins, cotters and collars should be carefully fitted. After assembly, careful inspection should be made to ensure that all collars, split pins, locking rings, etc., are in position, that the ends of split pins and split cotters have been properly opened and that all fastenings are tight.

Sheave pins (i.e., axles) of fixed type, particularly in overhead derricking gear, must be prevented from rotating (even if the sheave lubrication fails) by positive means such as keep-plates, square necks, or adequate " snugs " properly secured.

When cranes have been erected—perhaps even temporarily—on uneven or soft ground, collapses have occurred when the crane has been used for quite a short period. Even for the most temporary use, the ground on which the crane is to be supported should always be properly prepared.

When a crane is mounted on bogies the bogie platform below the mast must be stiff enough to take the maximum load without appreciable deflection, as otherwise the crane base will be overstrained and may fracture with possible collapse of the crane.

In the erection of guy derrick cranes, excessive tightening of any guy creates a real risk which must be avoided.

TESTS OF CRANE AFTER ERECTION

After erection, overload tests under the supervision of a competent person should be made on all the motions of the crane. In particular, the test load on Scotch or Guy Derrick cranes should be applied to produce the maximum uplift on each anchorage in turn. In the case of a Tower Derrick or of a mobile or other travelling crane the test load should be applied through the whole angle of slewing.

STABILITY OF DERRICK CRANE

A crane may be overturned as a whole (without the previous fracture of any part) as a result of inadequate anchorage, overloading, misuse of the crane, or mishandling of material. Methods of ensuring stability and avoiding failure from such causes are described below.

ANCHORAGES

The anchorages should obviously be of sufficient weight ; a reasonable margin on each is 50 per cent. above the weight required to balance the overturning moment on the crane when carrying the safe working load in any position ; and for exposed sites, involving bad weather conditions, there should be an addition to this margin. The anchorage weight at the foot of each back stay of a Scotch derrick crane is often fixed at three times the maximum safe working load of the crane, but this rough and ready rule should not be adopted without a check that the necessary degree of stability is thereby ensured.

The anchorage should be of as permanent a nature as possible, for, if parts of the weighting material are liable to be taken away for other purposes, overturning of the crane may easily result. A good form of anchorage for a crane fixed in one position at or near ground level (as in saw mills, masons' or builders' yards, etc.) consists of sufficiently massive concrete blocks in the ground to which the sleepers are secured by holding-down bolts. Easy means of access for inspection purposes should in all cases be provided at each connection of stay to sleeper.

A crane should not be used for installing or dismantling its own anchorage weights ; cranes have been overturned and serious injuries to workmen caused by such operations.

Where a Scotch derrick crane is erected on three towers, as in high building construction, the anchorage is usually effected by steel tie bars or rods passing down each of the two towers at the outer ends of the sleepers and secured to stout base platforms on which bricks or other weights are stacked. The steel tie bars or rods must be of reliable quality and should be tightened by

screw-couplings. The use of wire ropes for the purpose is unsatisfactory owing to their liability to stretch and the difficulty in maintaining equal tension in several returns of rope.

Anchorages for the back stays of Scotch derrick cranes which are only in temporary use, e.g., on a building site, are often formed of piles of heavy loose material. When this method has to be adopted the whole weighting mass should be made effective by placing it on a strong platform which concentrates the weight on the land ties, or sleepers, close to their junction with the back stays. The loose material should be bonded or kept in position by boxing the sides of the pile. None of the material should bear on the back stays as it might damage the stays, and in any event would have little anchoring effect.

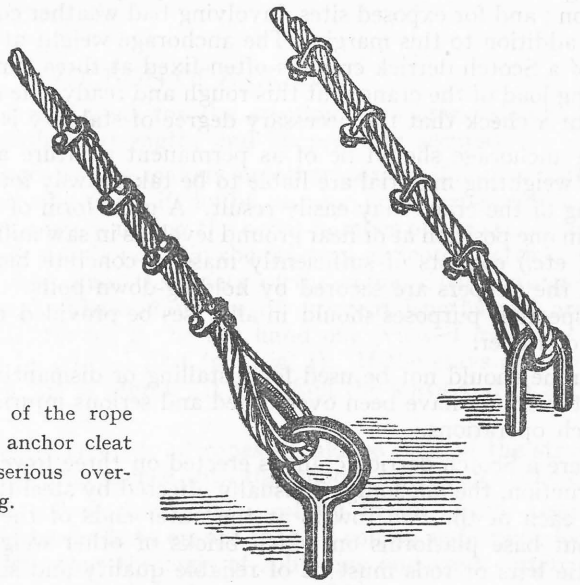
ANCHORAGES—GUY DERRICK CRANES

The guys of guy derrick cranes call for particular care ; they should, where practicable, be equally spaced (in plan view) and the base line or " spread " of each guy should be as long as possible.

A table should be fixed on each guy derrick crane showing the safe working loads for different radii of jib and for different base lines of guy ropes.

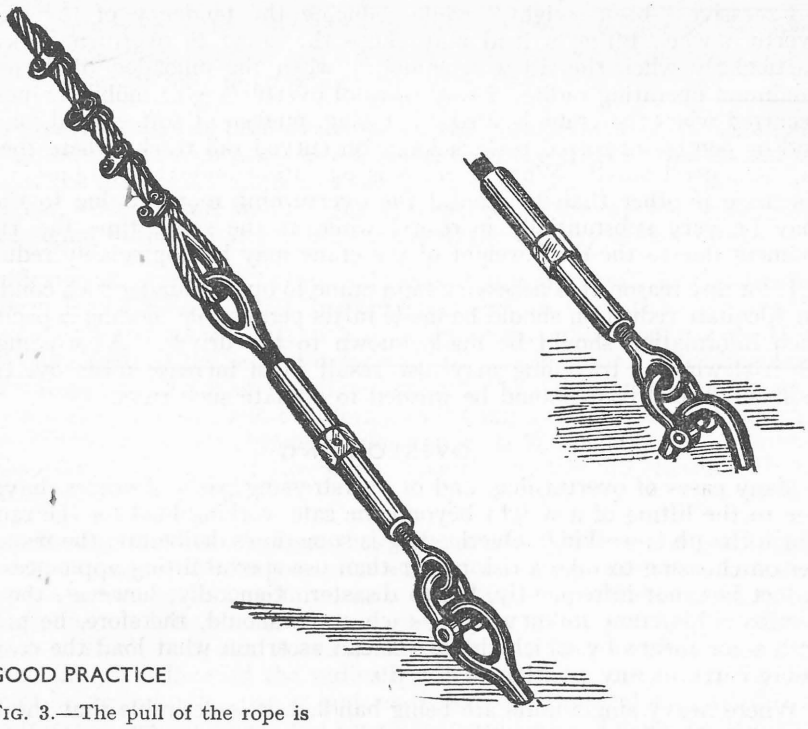
The details of each anchoring point for the guys need consideration. Parts of old structures have, by failure, proved unreliable ; and when new anchorages have been put in, these have not always been properly designed. " Cleats " or " brackets " (steel rods bent to U shape) are sometimes fixed in concrete anchorage blocks, but unless the pull of the guy rope is approximately in line with such an anchorage serious bending is likely to occur and overstress the metal. Fig. 2 shows how the pull of the guy rope produces bending stresses on badly installed anchor cleats or bolts, and Fig. 3 shows a correct form of installation.

In addition to the anchorages for the guys, anchorages or " kickers," to prevent slipping of the bearing member which is under the mast of a guy derrick crane, are required to resist the thrust due to the inclined jib and the side pull exerted by the ropes from the driving winch, which usually stands on a separate foundation.



BAD PRACTICE

FIG. 2.—The pull of the rope tends to bend the anchor cleat and may cause serious overstressing.



GOOD PRACTICE

FIG. 3.—The pull of the rope is applied axially and close to the surface of the anchoring block.

Before a guy derrick crane is erected on any part of the structure of a building (*e.g.*, on skeleton steelwork) the adequacy of the structure for the purpose should be considered. A point which should be emphasized is that the strength of ordinary steel joists in the horizontal direction is very much less than the strength in the vertical direction, and joists which are of sufficient strength to support the downward thrust may not have sufficient strength to resist the sideways-bending effect due to the thrust of the inclined jib and the pull exerted by the ropes passing to the winch, without some additional (temporary) bracing or support.

OVERTURNING—MOBILE CRANES

Mobile or travelling cranes depend for stability on their own dead weight and when in use overturning will occur if the resultant of the load and the dead weight of the crane falls outside the base area contained by the treads or wheels, in contact with the ground or rails. Where the base is of rectangular shape the maximum loading to ensure stability must be determined in relation to the length of the smaller side of the rectangle. Where, however, the base is triangular in form, as in the case of a three-wheeled crane, overturning is likely to occur if the resultant of the loaded crane falls outside the longest side of the triangle. In some cases, where the dead weight of the crane structure, undercarriage and mechanism is insufficient to ensure stability against the overturning moment of the load, anchorage weights in the tail of the crane are provided for in the design. Where these are removable care should be taken if they are removed for any purpose, e.g., during repair or dismantling, to see that they are replaced before the crane is again put to work.

Excessive " back weight," while reducing the tendency of the crane to overturn when lifting a load may cause the crane to overturn backwards, particularly when the jib is removed or when the unloaded jib is near its minimum operating radius. Many cases of overturning of mobile cranes have occurred when the crane is used on sloping, uneven or soft ground, on badly laid or poorly supported rail tracks or on curved rail tracks where the outer rail is superelevated. When a crane is operating under conditions in which the base is other than horizontal the overturning moment due to the load may be very substantially increased while at the same time the righting moment due to the dead weight of the crane may be appreciably reduced.

If for any reason it is necessary for a crane to operate under such conditions, an adequate reduction should be made in its permissible loading capacity and such information should be made known to the driver. A swinging load when slewing or travelling may also result in an increase in the overturning moment, and drivers should be warned to obviate such risks.

OVERLOADING

Many cases of overturning, and of overstressing parts of cranes, have been due to the lifting of a weight beyond the safe working load for the radius at which the jib is working. Overloading is sometimes deliberate, the responsible person choosing to take a risk rather than use special lifting appliances ; such an act has, not infrequently, led to disaster. Generally, however, the driver overloads his crane unknowingly ; each crane should, therefore, be provided with some means by which the driver can ascertain what load the crane can safely carry at any position of the jib.

Where heavy single units are being handled, it is desirable that the weight should be marked in a conspicuous place on each unit. The weight marked should always be an ascertained weight—*the marking of a " guessed " weight should never be allowed.*

Indication of safe loads and jib radii is usually given either by a table showing the safe working load for various angles or radii of the jib, or by a graduated scale automatically showing the safe working loads for the different jib radii ; the latter takes several forms.

One type is fixed to one side of the jib and consists of a plate marked with a scale showing loads and radii ; a pendulum pointer is pivoted below the scale and the raising or lowering of the jib causes a movement of the scale relative to the pointer. If the figures are legible and the pointer is working properly, the safe working load for any particular radius is shown on the scale ; but usually crane operators cannot read the indicator from the working platform, and it is often found that such indicators are not maintained in a satisfactory condition. An improved form of this type of indicator has a curved scale which faces the driver and is traversed by an extension of the pendulum pointer which is bent at right angles so as to cross the scale.

Another type consists of a circular scale across which a pointer (driven from the derricking drum) moves ; the radius and appropriate safe working load are indicated simultaneously on this scale. An indicator of this type may become inaccurate through stretching of the rope or failure to reset properly on renewing the rope.

Two other forms of indicator are straight graduated bars. With one form the bar is fixed and, as the jib moves in or out, a pointer moves along the bar and shows the appropriate safe working load and radius ; with the other the bar moves through a slot in a guide plate and shows these particulars at the edge of the slot.

The bar type of indicator should work accurately and can be seen by the crane operator, but it is obvious that none of the above-mentioned indicators

are of much service, unless the driver knows the actual weight of the load; they do not indicate whether the load being lifted is excessive and, in consequence, the crane may unknowingly be overloaded.

This disadvantage has been overcome by the development of the automatic safe load indicator which takes into account both the angle of the jib and the weight of the load being lifted and shows the crane driver, by a pointer or a light signal, when the safe load is being approached. If the safe load is exceeded a sound signal warns the driver and anyone in the vicinity of the crane.

Certificates of " approval " of several types of automatic safe load indicators have been issued by the Chief Inspector of Factories but this " approval " does not relieve any one who fits such an indicator to a crane from responsibility for the suitability of the indicator for that particular crane. Intending users should obtain the advice of the crane makers, the indicator makers or some other competent person before ordering or fitting an indicator of this type. Names of makers can be obtained from any of H.M. Inspectors of Factories and examples can be seen at the Safety, Health and Welfare Museum, Horseferry Road, London, S.W.1.

Many circumstances in which an automatic safe load indicator is particularly advantageous suggest themselves. The actual load on a crane may by its very nature in some cases be indefinite, as in grabbing under water or in waterlogged ground, or lifting furnace slag or scrap metal, or pulling " sections " from piles of stock steel, etc. A crane may pick up a load which is quite safe, but when the jib is lowered the radius increases and the safe radius for that load may be passed. If a proper automatic safe load indicator is fitted, any overloading will by reason of the signalling appliances at once be apparent both to the driver and to others in the vicinity.

Crane users should note that the purpose of the sound signal is primarily to warn persons, other than the driver, that the crane is overloaded. The driver should act on the visual indications given in regulating the operation of the crane and if these are intelligently observed the sound signal should seldom come into operation, and then only momentarily.

The initial and periodical thorough examinations of a crane cannot be regarded as complete unless the indications of the safe load indicator have been checked by means of a weight of known amount. Such a test should never be omitted after a crane has been taken down and re-erected.

Indicators can be obtained which can be instantly adjusted to suit different lengths of jib or variations of safe working load obtained by the use of outriggers or jacks but so far no indicator is available which will take account of variations in the safe load of mobile cranes when used on a sloping or uneven surface.

The fitting of appliances designed to secure the safe operation of cranes is in certain cases compulsory in order to comply with statutory requirements of the Factories Act or Regulations for particular classes of operations.

DISPLACEMENT OF MAST FOOT

If the jib of a Scotch derrick crane is near to one of the back stays, there is danger of the load lifting the pivot pin (at the bottom of the mast) out of its socket, with the probability of a general collapse; many fatal accidents have been caused by an occurrence of this kind. Such cranes should be fitted with means to prevent this happening, and one method is shown in Fig. 4.

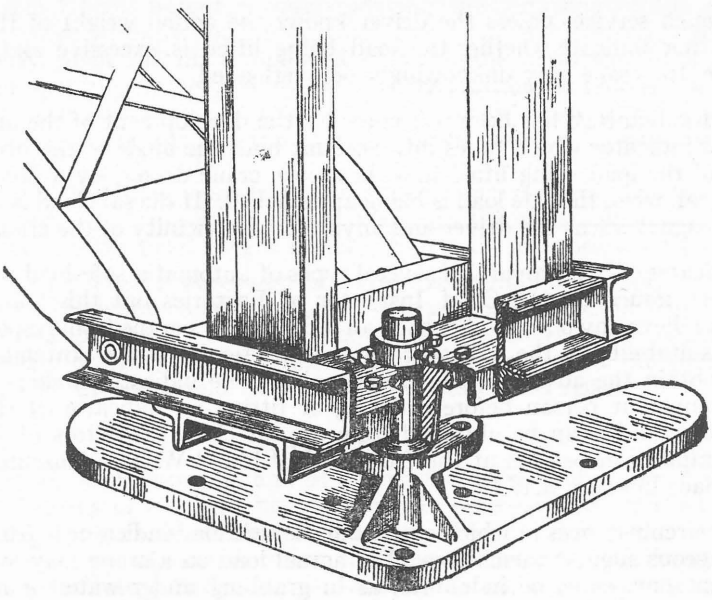


FIG. 4.—Method of preventing mast from being lifted from pivot. The pivot pin is secured to the base plate.

MISUSE OF CRANES

Cranes have been overturned or otherwise damaged by being used in a manner for which they were not designed. For example, a Scotch derrick should never be used for moving a load which is lying between the back stays. If the jib is mounted between the back stays, there is a tendency for the mast to be lifted off its pivot, as the anchorage weights do not counterbalance this overturning effect—see Fig. 5. If, on the other hand, the jib is properly mounted it is clearly impossible to get a vertical lift ; the tension in the inclined lifting rope causes a side pull at the top of the jib, forcing it against the near stay and creating bending stresses in the jib, and a downward pull which tends to lift the mast off the pivot bearing—see Fig. 6.

Cranes are designed for vertical lifting and not for exerting a side pull or an inward pull ; similarly a load should not be swung to land it inside or outside the radius at which the jib is set.

During lowering, the gearing should be kept engaged so that full control of the load is retained throughout by the driver or operators of the handles ; the sudden checking of a load by the brake alone imposes serious stresses on the whole structure and anchorages and may cause collapse or overturning.

FALLING JIBS

One of the commonest and most serious types of accident occurring in the use of Scotch derrick cranes is the fall of the jib. Such a fall may be due to failure of the derricking rope or part of the derricking mechanism ; failures are generally avoidable by making the parts of adequate strength, by proper design, and by subsequent test, proper maintenance and periodical examinations.

BAD PRACTICE

FIG. 5.—Stability of Scotch derrick crane endangered by use of jib between back stays.

BAD PRACTICE

FIG. 6.—Stability of Scotch derrick crane, endangered by dragging load lying in angle between back stays. (See p. 11.)

The fall of a jib may be due to any of the following causes :—

(1) The derricking clutch not being properly engaged with the clutch wheel at the beginning of the derricking operation and afterwards slipping out of gear.

(2) Lifting the pawl before the clutch is properly engaged with the clutch wheel.

(3) Disengagement of the derricking clutch whilst derricking out under power when the jib is at a steep angle and does not react quickly as the derricking rope is paid out.

(4) The load catching under a fixed structure during hoisting and then being suddenly released, throwing the pawl out of engagement with the ratchet wheel.

(5) Sudden arrest of the load during lowering causing a surge which throws the derrick pawl out of engagement.

(6) Inefficient interlock between the derricking clutch and pawl.

Falls due to any of the above causes usually occur on cranes with no independent brake for the derricking drum and can be prevented by the provision of an efficient interlocking mechanism between the derrick clutch and the derrick drum pawl or by a self-locking mechanism on the derricking drum. The interlocking mechanism must prevent the pawl being lifted until the clutch is fully engaged, and must also prevent disengagement of the clutch unless the pawl is fully engaged. Interlocking gear is necessary on both power and hand operated cranes.

An interlock is not necessary if the hoisting drum and derrick drum can be driven independently with each motion controllable by an independent brake.

Examples of interlocking mechanisms are shown in figures 7 to 10 and a self-locking mechanism in figure 11.

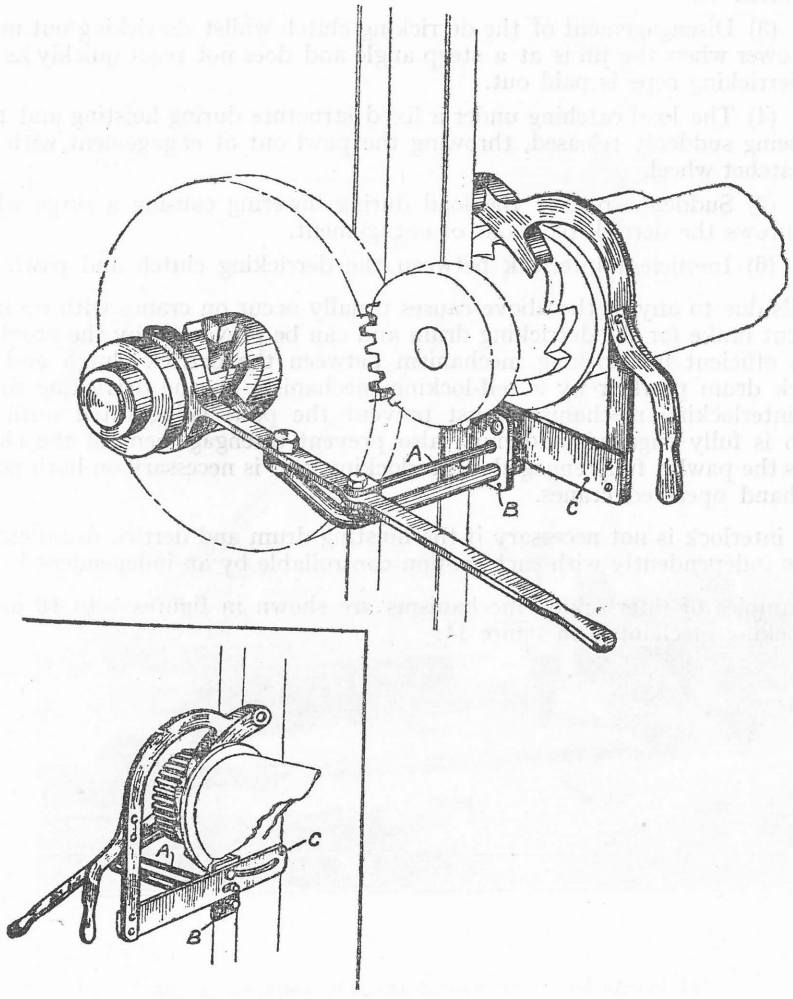


FIG. 7.—INTERLOCKING MECHANISM

(Suitable for hand or small capacity power-operated cranes.)

Rod A attached to the clutch lever passes through corresponding holes in plates B (attached to the crane framework) and C (forming part of the pawl operating lever) and prevents withdrawal of the pawl whilst the clutch is disengaged. When the clutch is engaged, rod A withdraws from the hole in plate C and allows the pawl to be raised. As the holes in plates B and C do not then coincide, the clutch cannot be disengaged.

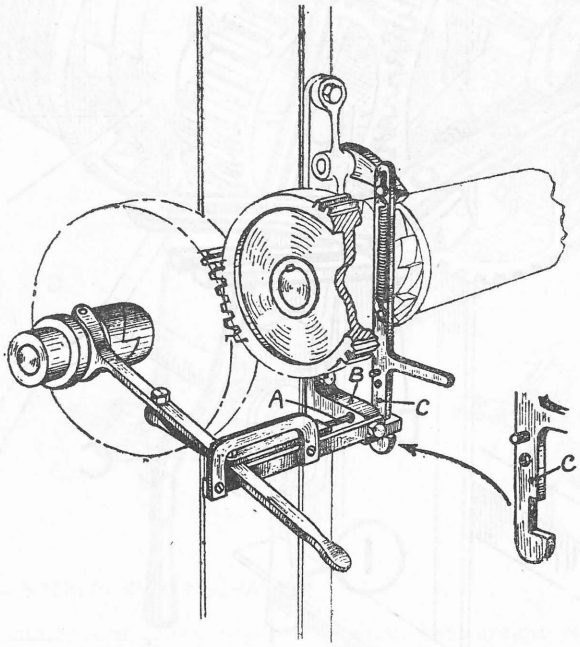


FIG. 8.—INTERLOCKING MECHANISM

This interlocking mechanism is similar in principle to that shown in Fig. 7, but is different in detail. During derricking operations the weight of member C and of the pawl is taken by the horizontal member through which C passes (see inset). The pawl is kept in engagement with the ratchet teeth by a spring when the clutch is out, and the slot in C only allows sufficient movement for the pawl just to clear the ratchet.

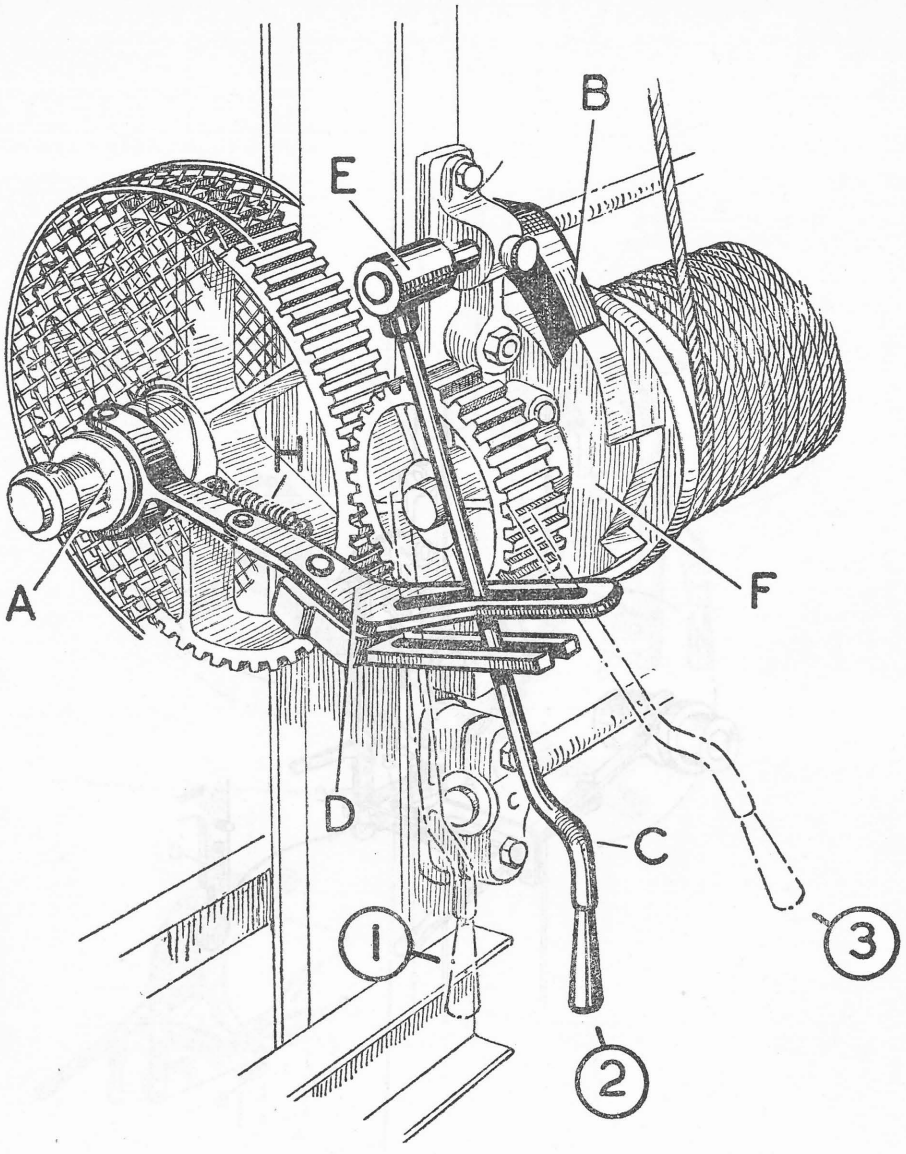


FIG. 9.—INTERLOCKING MECHANISM

Lever C moving in a specially shaped slot in the clutch fork lever D controls derricking clutch A and derricking pawl B.

The illustration indicates three positions for lever C. At position (1) clutch is out and pawl fully engaged ; at (2) clutch has moved into engagement and pawl is still fully engaged ; at (3) clutch remains in engagement and pawl has been lifted clear by movement of lever C from (2) to (3) engaging dog clutch housed in E.

H is a very powerful spring which controls the pin joint in D and prevents damage to the interlocking mechanism if the clutch is forced out momentarily while the pawl is in the disengaged position.

Except when held out by lever C, pawl B falls into engagement with ratchet F assisted by a small spring (not shewn).

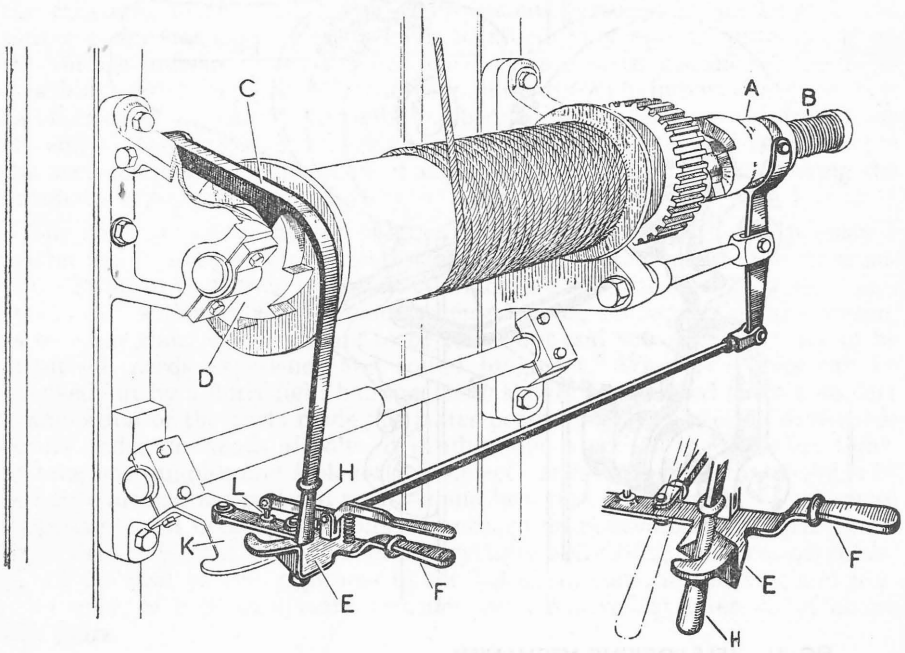


FIG. 10.—INTERLOCKING MECHANISM

Derrick clutch A is shown held out of engagement against compression spring B. Pawl C is held in engagement with the ratchet D by shaped plate E bearing against pawl handle H. When clutch operating lever F integral with plate E is moved to the right the clutch is engaged with the assistance of spring B ; E then allows the pawl handle H to be lifted sufficiently to allow C to clear ratchet D (see inset).

If clutch A is forced out during the operation of the crane, spring B ensures immediate re-engagement, and shaped plate E, as F moves to the left returns H to the pawl (C) engaged position.

Pin L on the end of the spring loaded lever engages in a hole in quadrant K when lever F is in the clutch out position.

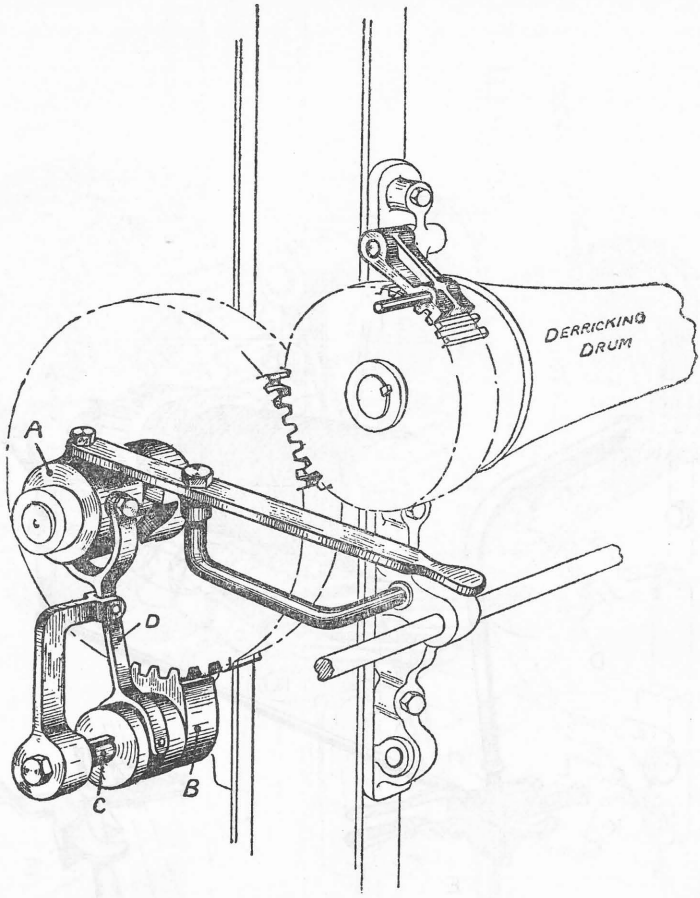


FIG. 11.—SELF-LOCKING MECHANISM

Toothed quadrant B slides on a feather key on spindle C and is connected by lever D to clutch A. Disengagement of the clutch causes the toothed quadrant to mesh with the gear wheel, thus preventing the rotation of the derricking drum.

Interlocking arrangements must be constantly maintained in effective working order and their efficiency should be checked at frequent intervals. For this purpose the jib should be lowered on to a trestle or other suitable support and the luffing rope relieved of tension so that the clutch and pawl can be easily moved into and out of engagement. The relative positions of these components should then be carefully observed to confirm that the clutch cannot be disengaged unless the pawl is fully engaged and that the pawl can only be withdrawn when the clutch is fully engaged.

FAILURES DUE TO FRACTURES OF PARTS

Fractures of vital parts have been the causes of accidents, but with more reliable materials now available such failures should decrease. British Standard No. 327, Parts I and II, for derrick cranes, lays down minimum standards of material and strength of parts which should be observed on all new cranes.

In the case of cranes used for building operations these standards have been given legal recognition—see the Building (Safety, Health and Welfare) Regulations, 1948. The importance of proper maintenance and use has already been emphasised.

TIMBER MEMBERS

The use of cranes having timber structural members is prohibited on building operations and there is convincing evidence of the unsuitability of timber for use as principal members of cranes. For example, expansion and contraction of the timber due to atmospheric changes may result in slackening of bolts; individual bolts may break through being overstressed due to variations in the resistance of the timber, and bolts become corroded by moisture in the timber round the bolt holes. Timber members may appear quite sound on the surface and be rotten inside. Accidents are often caused by the bolts attaching gland irons to back stays pulling through impoverished timber. In other cases the end of the timber embedded in the cast iron shoe or cap at the end of the jib or mast breaks away. These typical cases of failure indicate the need for proper examination of such timber parts by a person having the necessary experience for such duty.

The necessity of taking out bolts embedded in timber parts is obviously a matter which must be left to the discretion of the person making the examination. Damage to the timber of stays which are subjected to alternate " pull and push " action must be avoided when possible; consequently the decision, as to when gland iron bolts are to be taken out and when they are not to be disturbed, needs experience and sound judgment. When the bolts can be knocked out by a fairly light hammer, they should be removed and a complete examination of the parts made; as water penetrates and corrosion sometimes occurs under the heads of bolts, it is advisable, where all the bolts are tight, to take out samples and look for this defect. It is important that bolts subjected to alternating pull and push, should be a tight fit in the holes, otherwise " racking " and breakage of bolts will occur; on reassembling the parts new bolts should be put in where necessary and well-fitting ferrules, or tubes, should be used to give tightness in the holes. In some instances gland iron bolts have, as a precautionary measure, been renewed at intervals of about five years.

CORROSION OF METAL PARTS

Most derrick cranes are used in the open air and corrosion of metal parts has caused many failures; all practicable steps should therefore be taken to detect such wastage. The less-readily accessible and hidden parts, such as gland irons (underside at the bend particularly), bolts, derricking ropes, chains, rods, links and locking pins should be examined regularly and painting or greasing should be properly carried out.

FAULTY LUBRICATION

Fractures of working parts of cranes with very serious consequences have occurred owing to neglect of lubrication of the working parts. For instance, failure of lubrication of sheave pins and axles has in many cases led to rapid wear and ultimate fracture; in other cases seizure of the derricking sheave on its pin has led to the unscrewing of fastenings and the fall of the jib. Seizure of a jib-head sheave on its pin obviously results in the rapid wear and deterioration of the rope. Accidents due to such causes can only be prevented by frequent attention to the lubrication of every point where friction may occur. Any pulleys which are not easily accessible should be of the self-oiling type. Where parts are designed to be lubricated through oil holes, care should be taken to check that the holes are clear and, when replacement parts are being fitted, that holes are provided for lubrication and are in the correct positions.

Sheave pins should be taken out for examination whenever a crane is dismantled and at such other times as may be practicable.

Heavy grease will withstand the effects of weather better than oil, but it should be thinned in cold weather to ensure penetration into the bearings, and should not be used for bearings designed for oil lubrication.

The driver or greaser should, when lubricating, make a habit of ascertaining that cotters and split pins are in proper position and that screws, bolts and nuts are tight. Attention to these details at such times involves little extra trouble and the assurance gained more than compensates for the effort made.

ROPES, ROPE ATTACHMENTS, DRUMS, PULLEYS, ETC.

Wire ropes are much used for the hoisting and derricking motions of cranes and when of suitable quality they are reliable. As a rule they show signs of wear, deterioration, or injury before actual fracture takes place and the regular examination of the ropes, which should include, where necessary, the exposure of splicings by removal of their seizing wire or spunyarn, is therefore an effective step towards accident prevention ; broken wires or corrosion are usually the first signs of dangerous conditions.

Wire rope generally has a hemp core, but in some cases, as when used for lifting hot metal, a soft iron core is used. Numerous factors influence the length of life of a wire rope—good quality and a sufficient degree of flexibility in the wire strands and good workmanship in manufacture are very important. As a rule the larger the diameter of drums and pulleys, the longer the life of the rope, but larger drums require larger gear wheels and more weight in other parts. A new rope to replace an old one should not be of less flexible construction than that originally supplied by the crane maker : the fitting of less flexible (and cheaper) ropes is very bad practice.

The drum barrels and pulley grooves should be smooth and should give a good bedding surface for the rope or chain. Each drum should, where practicable, be of sufficient size to permit of the ropes being wound in a single layer, but whilst overlapping of the rope is undesirable, in some cases it may be unavoidable.

Where necessary, guide pulleys or rollers should be provided to prevent the rope chafing against parts of the crane structure.

The derricking rope should when possible be long enough to allow the jib to be lowered to the horizontal position, and all working ropes should be long enough to ensure that in any working position there are never less than two complete turns of rope on the drum ; the frictional grip of the rope on the drum thus prevents the full load coming on to the rope attachment. Still, the possibility of allowing the rope to run out too far is sometimes present and, in view of this, the rope attachment should be designed to bear the pull corresponding to the full load. Rope attachments by open hooks have led to accidents and should be avoided. One example of a secure type of rope attachment is shown in Fig. 12. A thimble splice is made at the end of the rope, the thimble fits into a slot in the body of the drum end and a set screw with plain shank screwed into the drum passes through the thimble ; the pin should be strong enough to carry the full load. No arrangement in which the rope bends sharply between the anchorage and the general coiling surface of a drum can be regarded as satisfactory.

Where the part of the rope between the drum and the jib-head pulley slackens in working (as, for instance, a grab rope), a guard should be fitted to prevent the rope from leaving the jib-head pulley.

It is advisable that wire ropes should be regularly lubricated (makers recommend once every 10 days) whether the crane has been at work or not.

When it is necessary to store wire rope, a coat of good quality grease should be applied and the rope should be kept in a dry place, otherwise internal corrosion (which cannot be detected by examining the exterior) may occur with serious consequences when the rope is again put into service.

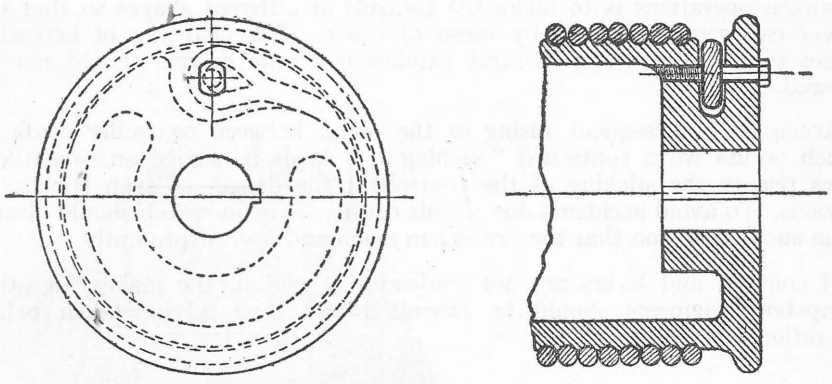


FIG. 12.—Good type of attachment of rope to drum.

BRAKES AND CONTROLS

Every derrick crane should be fitted with one or more brakes on the hoisting and derricking motions, and where slewing gear is fitted, on the slewing motion. On hand-operated and single motor cranes, one brake usually controls both the hoisting and derricking motions ; where two brakes are fitted each should be capable of holding the full load with an adequate margin of safety. The brakes play an important part in the safety of a crane and must be maintained in efficient working condition ; the screws or rivets holding linings should be deeply countersunk and so fixed that they will remain secure when worn. There should also be a " taking-up " arrangement by which compensation for the wear of the linings can be made. Brake pedals or levers should be positioned and adjusted so that full pressure can be applied without risk of the pedal or lever coming into contact with the floor or other obstruction.

Brake bands when not in use should be clear of the drums : otherwise unnecessary wear will take place and unreliability result. When other means of keeping bands clear are not available, a light spring attached near the top of the band and to a fixed bracket on the framing or cabin may be found satisfactory.

Where weighted-lever brakes are used, the weights should be securely bolted to the levers, to avoid the risk of slipping off through vibration ; some maintenance engineers put an extra clip or bolt on the lever as a safeguard against the slacking back of the fastening.

The efficiency of a brake depends on the amount of friction between the braking surfaces ; consequently, the presence of oil, grease or graphite will lead to slipping and may give rise to danger. Water is also a lubricant and where present in quantity reduces very considerably the friction between the braking surfaces. Failure of brakes has, in fact, occurred by rain water in quantity getting on to them ; failure has also occurred in winter time by dripping water freezing and forming ice on the brake bands; these causes of failure are avoidable by protecting brakes from wet.

As the prompt operation of brakes is essential, brake levers should be so placed that the driver can readily operate them.

Control handles or levers should be placed so that they can be easily operated by the driver, and they should be provided with locking arrangements to prevent accidental movement and starting of any of the crane motions. Accidents have been caused by operation of a wrong lever or control and all controls should where practicable be marked to show their purpose and direction of movement for a particular operation. A further precaution against mistaken operations is to make the controls of different shapes so that the driver can recognise them by sense of touch. The fastening of extension pieces to brake levers or control handles by crane drivers should not be allowed.

Arcing and consequent fusing of the metal between controller contacts, which occurs when continued "inching" of loads is carried on, sometimes gives rise to the sticking of the controller; the danger of such sticking is obvious. To avoid accidents due to this cause, the main switch should always be in such a position that the driver can reach and open it promptly.

If controls and levers are not conveniently placed, the makers or other competent engineers should be consulted and their advice taken before alterations are made.

FENCING OF GEARING AND DANGEROUS MACHINERY

The requirements of the Factories Act and certain codes of Regulations affecting particular classes of operations make it necessary for all dangerous parts of the crane machinery, whether power or hand operated, to be securely guarded unless equally safe by position or construction. Such dangerous parts include flywheels, gear wheels, couplings, belt and chain drives, revolving shafts, keys, set screws, etc. These obligations apply not only to occupiers of the premises in which cranes are used, but extend, in certain cases, to those who own, sell, let on hire, erect, install, work or use a crane. A factor which should influence the type of guarding of crane gearing is that the teeth of a wheel sometimes break and, whilst the breakage of a wheel on many machines may not give rise to danger to the operative, the breakage of wheels on cranes may give rise to very serious risks. In consequence tooth gearing should not be hidden any more than is necessary for the purpose of guarding it safely. Fig. 13 shows types of guarding considered satisfactory for different arrangements of tooth gearing of cranes.

REVERSING MECHANISM

On steam-driven cranes effective means of locking the lever controlling the reversing mechanism should be fitted; accidental reversal which might have serious consequences will thus be avoided.

FIRE DANGERS

The necessity of precautions against outbreaks of fire has been demonstrated by fires which have occurred in crane cabins after cranes have been left unattended; in several such cases, in addition to other effects, the derricking rope has been so damaged that the jib has fallen. Fire-proof surroundings should be provided for stoves and chimneys.

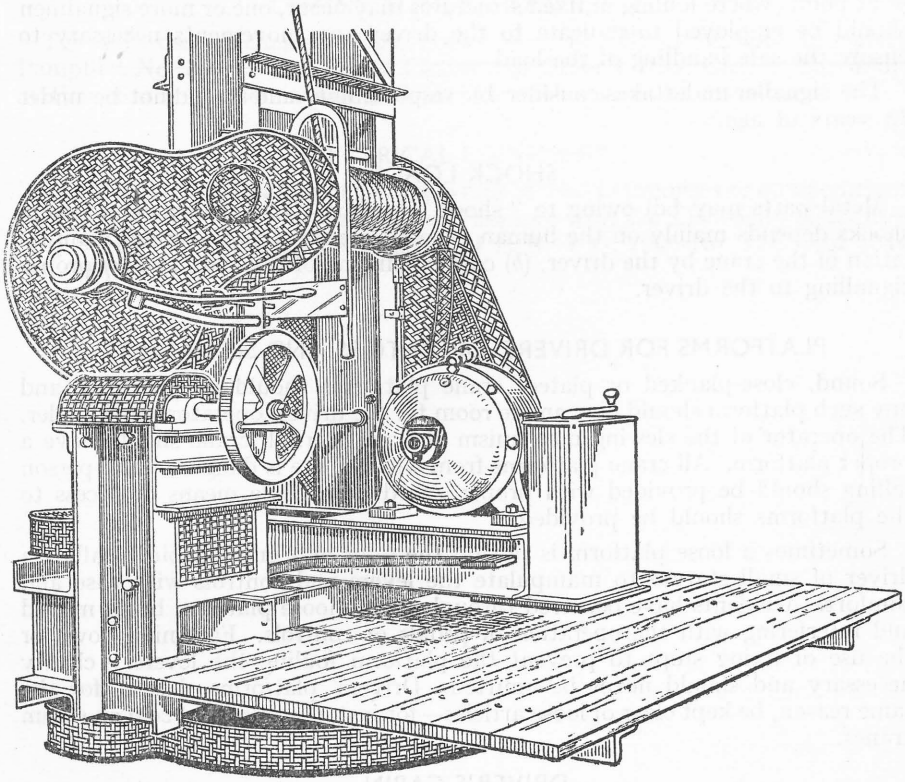


FIG. 13.—Shows toothed gearing enclosed in wire-mesh guards permitting ready examination.

DRIVER'S QUALIFICATIONS

No person should be given sole control of a crane until he has shown that he is competent to operate it safely. In the case of certain classes of work a minimum age for a person who may be allowed to operate a crane is specified by Regulations. During the normal operation of a crane no one but the driver should be allowed to be in the cab or on the control platform.

SIGNALLING

When the driver cannot see the load at the beginning and end of its travel or at points where fouling of fixed structures may occur, one or more signalmen should be employed to indicate to the driver any movements necessary to ensure the safe handling of the load.

The signaller undertakes considerable responsibility and should not be under 18 years of age.

SHOCK LOADS

Metal parts may fail owing to " shock " loading. The avoidance of severe shocks depends mainly on the human element, *i.e.*, on (*a*) the careful manipulation of the crane by the driver, (*b*) careful slinging of the load, and (*c*) proper signalling to the driver.

PLATFORMS FOR DRIVERS, OPERATORS AND SIGNALLERS

Sound, close-planked or plated, crane platforms should be provided, and any such platform should give ample room for the driver, operators or signaller. The operator of the slewing mechanism of a guy derrick crane should have a proper platform. All crane platforms from which there is danger of any person falling should be provided with proper guard rails. Safe means of access to the platforms should be provided.

Sometimes a loose platform is put on the floor of a crane cabin to allow a driver of small stature to manipulate the levers and controls with ease and comfort. Accidents have occurred through such a loose platform being moved and interfering with the operation of pedals or controls. Fastening down or the use of fixing stops to prevent the platform fouling the levers is clearly necessary and should never be omitted. Drivers' platforms should, for the same reason, be kept clear of loose articles—for instance, pieces of coal on steam cranes.

DRIVER'S CABIN

The driver should be protected from the weather by a properly enclosed cabin, provided with windows that give the maximum possible view of all work which the crane has to do, including, in the case of a travelling crane, visibility when the crane is travelling in either direction. The cabin should be so constructed as to provide ready access to parts of the crane which require to be inspected, lubricated or otherwise maintained periodically. In cold weather the cabin should, where possible, be suitably heated.

MAINTENANCE

Frequent inspections, with repairs or replacements of defective parts, are essential for the maintenance of cranes in a safe working condition. The careful driver should (unless these particular duties are definitely allocated to some other person) look over his crane at least once a week, searching for possible defects in ropes and for cracks (particularly in cast iron parts such as wheels and clutches), attending to the security of locking pins, cotters, screws and nuts, and making sure that the bearing surfaces have been properly lubricated.

CRANE NOT TO BE LEFT WITH LOAD SUSPENDED

A driver should never leave a crane with a load suspended.

BRACING OF SCOTCH DERRICK TOWERS

Accidents have occurred when the towers on which cranes of this type have been erected were inadequately braced together. The towers must be rigidly braced together by horizontal struts and diagonal ties. The sleeper legs should not be considered as struts bracing the tops of the towers.

CHAINS, SLINGS, HOOKS, ETC.

The safe use of chains, slings, hooks, etc., is fully dealt with in Safety Pamphlet No. 3 on " The Use of Chains and Other Lifting Gear". The information contained therein will be found of much service to crane users.

ELECTRICAL EQUIPMENT

The electrical equipment of a crane which is used in premises or on operations to which the Factories Acts apply must comply with the Electricity (Factories Act) Special Regulations, 1908 and 1944 (S.R. & O. 1908 No. 1312 and 1944 No. 739).

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APPENDIX

Specific references to cranes in the Factories Acts and Regulations.

1. (*a*) Factories Act, 1937. Section 24.†
   (*b*) Building (Safety, Health & Welfare) Regulations 1948 (S.I. 1948 No. 1145.)
   (*c*) Docks Regulations, 1934 (S.R. & O. 1934 No. 279.)
   (*d*) Shipbuilding Regulations. (S.R. & O. 1931 No. 133.)

2. *Factories Act Forms for use in the Inspection, Test and Examination of Cranes.*

	Factory Form
(*a*) Factories.	
Fourteen monthly examinations	88
Test and examination	*
(*b*) Building Operations.	
Weekly inspections	91 Part I
Anchorage tests for Scotch derricks	91 Part II
Fourteen monthly examinations	96
Test and examination	
(*c*) Docks.	
Twelve monthly examination	99
Test and examination	1945
(*d*) Shipbuilding.	
Twelve monthly examination	95
Test and examination	*

* No official form, but Form 96 or 1945 may be used.

† The application of this Section as laid down in this Act is extended by Section 14 of the Factories Act 1948.

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